

Rhubarb Juice as a Natural Antibrowning Agent

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ABSTRACT: To search for natural antibrowning agents, rhubarb juice was tested on fresh-cut apple slices and found to have a potent effect. Liberty apple slices were treated in various concentrations of rhubarb juice (5% – 100%), and the rate of discoloration at room temperature was measured by a Hunter Colorimeter. Apple slices treated in the 5% – 10% solution showed browning activity with δL values of 2.3 – 2.5 at two hours. However, the concentrations of rhubarb juice above 20% inhibited apple browning effectively with no change in the L value for several hours. Analysis of oxalic acid in rhubarb juice showed that the 20% solution contained about 67 mg/100g.

Key words: natural antibrowning agents, fresh-cut apple, browning activity, oxalic acid, rhubarb juice

Introduction

SINCE THE U.S. GOVERNMENT'S 1986 BAN ON THE USE OF sulfites on fresh fruits and vegetables, the food industry has been searching for effective antibrowning agents to control discoloration. Recently, various antibrowning substances have been reported. Among them, cysteine, 4-hexylresorcinol, and kojic acid are well known. However, these chemicals have limited commercial use because of safety problems, cost, and government regulation. In addition, the demand for antibrowning agents from natural products is strong. Considerable research has been conducted on natural substances, including amino acids (Kahn 1985), fig latex (McEvily 1991), honey (Oszmianski and Lee 1990), the Maillard reaction products (Nicoli and others 1991; Lee and Lee 1997), pineapple juice (Lozano-de-Gonzales and others 1993) and papain extract (Richard-Forget and others 1998). However, none of these agents are commercially used for fresh-cut fruits and vegetables.

In a comprehensive study of effective antibrowning agents, more than three dozen chemical compounds were tested on apple slices and oxalic acid was found to be an excellent browning inhibitor that has an efficacy similar to kojic acid, cysteine and 4-hexylresorcinol (Son and others 1999). Oxalic acid is commonly found in many fruits and vegetables, including spinach, rhubarb, and beet root at concentrations of 100 – 780 mg/100g fresh weight (Hodgkinson 1977). Therefore, an attempt was made to utilize extracts from these vegetables as antibrowning agents on fresh-cut apple slices. We report an excellent natural antibrowning agent derived from rhubarb.

Materials and Methods

FRESH RHUBARB OBTAINED FROM A LOCAL GROWER WAS WASHED and cut into small pieces (smaller than 2.5 cm). Small pieces of rhubarb were diced using a Urschel dicer (Urschel Lab. Inc., Valparaiso, In., U.S.A.) and pressed using a screw extruder (Model JP 4; Buffalo Hammer Mill Corp., Buffalo, NY, U.S.A.) with approximately 80% (w/w) yield. The juice was filtered through cheesecloth and stored in a refrigerator until use.

Liberty apples were washed and sliced longitudinally using a stainless steel hand slicer and then dipped immediately into rhubarb juice solutions for 3 min. After draining, the treated samples were kept on a laboratory bench at room temperature for observation. In order to find the lowest concentration that effectively inhibits apple browning, the concentrations of rhubarb juice as dipping solutions were gradually decreased from 100% to 5% by adding water.

The changes in flesh color of the treated apple slices were measured by a Hunter Colorimeter (Model D-25; HunterLab Corp., Reston, Va., U.S.A.) at designated time intervals. The de-

gree of browning was expressed by "dL" value (L value at initial – L value at given time). The results were expressed as a mean value from 10 replicated measurements per sample. ANOVA tests ($P < 0.05$) were carried out using SAS (1990). Oxalic acid content in rhubarb juice was analyzed by a high performance capillary electrophoresis (HPCE), using an Hewlett Packard 3D Capillary Electrophoresis system that consists of a CE unit with built-in diode-array detector and an HP ChemStation, with Organic Acids Buffer (Part 8500-6785; HP Corp., Palo Alto, Calif., U.S.A.).

Results and Discussion

SINCE RHUBARB JUICE IS PRACTICALLY COLORLESS WITH A SLIGHT pinkish cast, there was no visual effect on apple color after dipping. Apple slices dipped in the 100% rhubarb juice showed no color change at all. Therefore, the antibrowning activity of diluted rhubarb juice was examined at the various concentrations (100%, 80%, 60%, 40%, 20%, 10% and 5%). The change in the L value during the two-hour period is shown in Table 1. Ascorbic acid (Grade USP-FCC; J.T. Baker Inc., Phillipsburg, NJ, U.S.A.) was used as a reference inhibitor to compare with rhubarb juice. Antibrowning activity of 1% ascorbic acid was effective for only 10 min. As the reducing power of ascorbic acid was depleted, the brown color developed rapidly within 20 min with δL value of 0.8 and reached the maximum δL value of 8.2 at two hours. Antibrowning activities of diluted rhubarb juice solutions on fresh-cut apple slices varied greatly. Apple slices treated with 5 – 10% rhubarb juice began to brown after 10 min and attained an δL value of 2.3 – 2.5 after 2 hours. However, concentrations of rhubarb juice solution above 20% inhibited apple browning effectively with no change in the L value. The analysis of significance of differences among different concentrations at each time interval showed in Table 1. Based on the least significant difference

Table 1. Inhibition of apple slice browning by rhubarb juice.

Antibrowning agents (w/w)	δL^* value at designated time interval (min) ¹					Oxalic acid content (%) ²
	10	20	30	60	120	
1% ascorbic acid (Ref)	0.03	0.84	2.0	8.22	8.19	0
5% rhubarb juice	0.77	0.92	0.94	1.45	2.56	0.02
10% rhubarb juice	0.94	0.93	1.01	1.24	2.30	0.03
20% rhubarb juice	0.01	0.06	0.02	0.08	0.05	0.07
40% rhubarb juice	0.01	0.01	0.02	0.01	0.02	0.13
60% rhubarb juice	0.09	0.04	0.02	0.05	0.04	0.20
80% rhubarb juice	0.07	0.03	0.01	0.01	0.01	0.26
100% rhubarb juice	0.01	0.08	0.01	0.01	0.01	0.33
LSD 0.05	0.29	0.57	0.97	1.12	1.36	

¹ Data are means of ten replicates.

² Data are means of three replicates.

* δL value was defined as in L value at initial – L value at given time.

(LSD_{0.05}) at 2 hours period, five to ten percent rhubarb juices did not effectively prevent the browning of apple, but the concentrations above 20% were very sufficient ($p < 0.05$).

The oxalic acid content in rhubarb juice analyzed in this study was 334 mg/100g juice. Based on this result, the 10% juice contained approximately 0.03% oxalic acid and the 20% juice contained 0.07% oxalic acid. The value of 0.07% oxalic acid in the 20% juice, the approximate minimum concentration required to inhibit browning, is closed to the 0.05% minimum concentration determined in a previous study (Son and others 1999). Therefore, the antibrowning activity of rhubarb appeared to be mainly due to oxalic acid in rhubarb juice. Antibrowning activity was also tested after pasteurizing the rhubarb juice (pH = 4.3) at 80 °C for 5 min. The heat treatment on rhubarb juice did not affect antibrowning activity on apple slices ($p < 0.05$). In addition, rhubarb juice was treated with active carbon to obtain a colorless and odorless liquid. This clear solution also proved as active as non-treated rhubarb juice ($p < 0.05$).

We conclude that rhubarb juice is a very effective natural antibrowning agent for fresh-cut fruits and vegetables, and has a strong potential for commercial use because it is easily obtainable, inexpensive, safe, natural, and free of regulatory constraints.

References

- Hodgkinson A. 1977. Oxalate content of foods and nutrition. In: Hodgkinson A, editor. Oxalate content of foods and nutrition in oxalic acid in biology and medicine. London: Academic Press. p 196-197.
- Kahn V. 1985. Effects of proteins, protein hydrozates and amino acids on *o*-dihydroxyphe-
nolase activity of polyphenol oxidase of mushroom, avocado, and banana. *J Food Sci* 50:111-115.
- Lee GC, Lee CY. 1997. Inhibitory effect of caramelisation products on enzymic browning. *Food Chem* 60:231-235.
- Lozano-De-Gonzalez PG, Barrett DM, Wrolstad RE, Durst RW. 1993. Enzymatic browning inhibited in fresh and dried apple rings by pineapple juice. *J Food Sci* 58:399-404.
- McEvily AJ. inventor; Enzytech Inc., assignee. 1991 Jan. 1. Method of preventing browning in foods utilizing protease free latex extracts particularly from figs. U.S. Patent 4,981,708.
- Nicoli MC, Elizalde BE, Pitotti A, Lericri CR. 1991. Effect of sugars and Maillard reaction products on polyphenol oxidase and peroxidase activity in food. *J Food Biochem* 15:169-184.
- Oszmianski J, Lee CY. 1990. Inhibition of polyphenol oxidase activity and browning by honey. *J Agric Food Chem* 38:1892-1895.
- Richard-Forget FC, Cerny MG, De-Richard DP, Fayad-Eldahouk NN, Varoquaux PJ. 1998. Antibrowning efficiency of papaine extracts. *Proceed. 19th International Conference on Polyphenols*, Lille. p 265-266.
- SAS Institute Inc. 1990. SAS User's Guide to the Statistical Analysis System. Version 6.12. Raleigh, N.C.: SAS Institute.
- Son SM, Moon KD, Lee, CY. 1999. Antibrowning capacity of oxalic acid and its application in apple processing. *Proceed. 10th IUFOST*; Sydney. p 124. MS 19991221

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